§24. Effect of Test Equipment Configuration on Interlaminar Shear Fracture and Strength of Glass Fiber Reinforced Plastics

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Glass fiber reinforced plastics (GFRP) is an electric insulation material for a superconducting magnet. An epoxy resin type GFRP with glass clothes is commonly used for many magnets and it is well known that the radiation resistance is not strong because of an organic material. The interlaminar shear strength (ILSS) has been investigated to clarify the fracture behaviors of GFRPs and the test procedures have been discussed empirically.

When the radiation effect of GFRPs is investigated, the smaller samples are welcomed because of limited space for irradiation. In addition, it is better to determine ILSS using small number of specimens. Since there is not enough data on the effect of test equipment configuration, the effect of radius of loading and supporting jigs is investigated systematically.

To simplify the research purpose, the test conditions except for the radius were not changed. The ILSS test was performed by a short beam test process (three-point-bending). The specimen configuration was 2.5 mm thick, 10 mm wide and 15 mm long, and the span was 12.5 mm. Stroke rate was 0.75 mm/min and the short beam test was carried out in liquid nitrogen (77 K). The ILSS was obtained by the following equation: $\sigma_{ILSS} = (3 \times P_B) / (4 \times b \times h)$, where P_B is the maximum bending load, b is specimen width (10 mm) and h is specimen thickness (2.5 mm).

The radii of the loading and supporting jigs are designated as R_l and R_s for the radius of loading jig and that of supporting jig. They were changed from 1mm to 7 mm by 1 mm. Figure 1 shows the loading and supporting jigs used. The combination of loading and supporting jigs was as follows: (1) Cases that R_l and R_s are the same. (2) Cases for supporting jig radius of from 2 mm to 5 mm under constant loading jig radius of 6 mm. (3) Cases for loading jig radius of from 1 mm to 5 mm under constant supporting jig radius of 7 mm.

The results are shown in Fig. 2 and 3. In the case that R_l and R_s are the same, round symbols show the bending fracture and square symbols show the interlaminar shear fracture. When the radius is smaller than 5 mm, all specimens showed bending fracture. However, when the radius became larger than 4 mm, the interlaminar shear fracture occurred.

When the radius of loading jig was 6 mm, the interlaminar shear fracture occurred even at the supporting jig radius of 3 mm. When the radius of supporting jig was 7 mm, translaminar fracture was observed smaller loading jig radius which showed that the shear fracture happened on the plane between the loading point and the supporting points. The interlaminar fracture occurred even at the supporting jig radius of 3 mm.

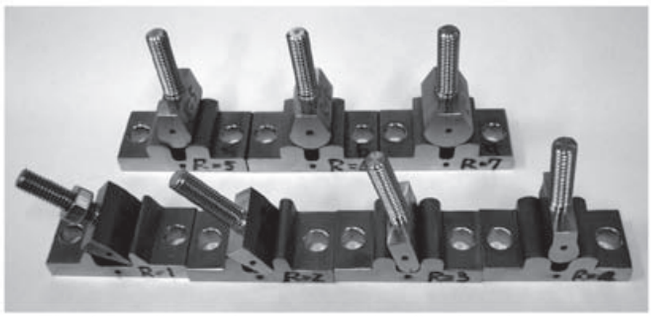

Fig. 1 Loading and supporting jigs for short beam test.

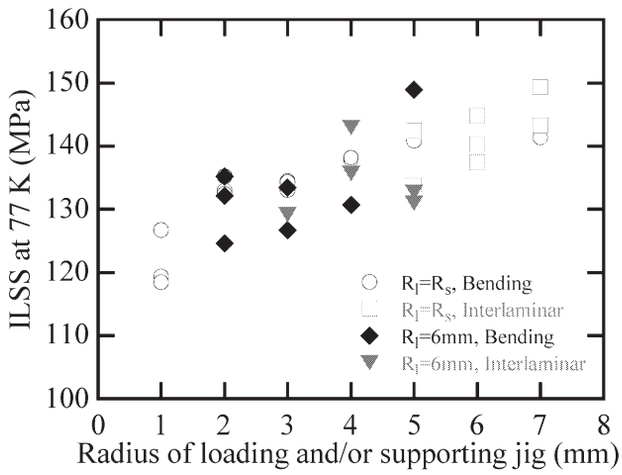

Fig.2 ILSS test results of cases that R_l and R_s are the same, and cases for supporting jig radius of from 2 mm to 5 mm under constant loading jig radius of 6 mm.

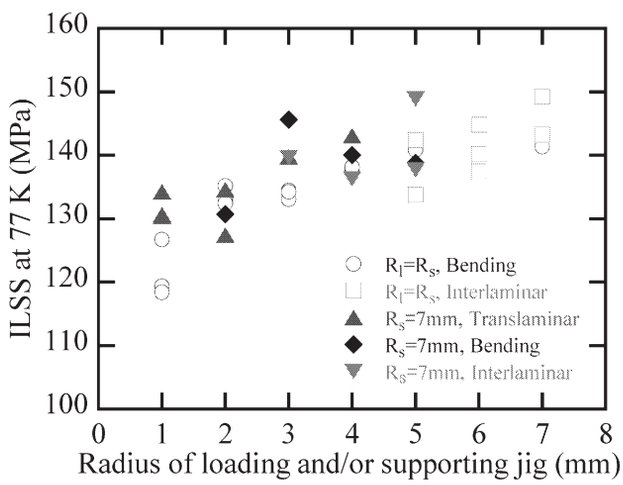

Fig. ILSS test results of cases that R_l and R_s are the same, and cases for loading jig radius of from 1 mm to 5 mm under constant supporting jig radius of 7 mm.

From these results, it would be concluded that larger radius of the loading supporting jigs is better for generating the interlaminar fracture and ILSS will scatter +/- 10 MPa around the average of about 140 MPa. In the case of larger radius supporting jig, the contact points shift to inside resulting in decreasing the span. And the curvature radius becomes larger and local deformation is hard to occur.